

## Short Term Scientific Mission (STSM) 2014

# Fate and removal of organic micropollutants during anaerobic digestion of sewage sludge

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## Objectives

The research was conducted in order to highlight, first of all, the presence of Organic Micropollutants (OM) in sewage sludge, and, secondly, their fate during anaerobic digestion (AD) processes (both in mesophilic and thermophilic conditions). This can be reasonably considered as a “hot topic”, due to the lack of consistent data in the scientific literature, as a consequence of the complexity in the detection of OM in the sludge matrix.

## Methodology

Two (a mesophilic and a thermophilic) laboratory-scale ( $\approx 15$  L volume) AD reactors were operated for 4 months with sewage sludge. The fed sludge was a mix of primary (70%) and secondary (30%) sludge coming from Santiago de Compostela WWTP. The determination of OM concentrations in sludge was carried out under steady-state conditions: the main operating conditions were: SRT = HRT = 28 d; OLR  $\approx 1.2$  g COD/(L·d). Two sampling campaigns were conducted on grab samples in order to determine the following substances: Celestolide, Galaxolide and Tonalide (musk fragrances); Carbamazepine, Diazepam, Fluoxetine and Citalopram (psycho-active drugs); Ibuprofen, Naproxen and Diclofenac (anti-inflammatory); Erythromycin, Roxithromycin and Sulfamethoxazole (antibiotics); Trimethoprim, Triclosan, Octylphenol, Nonylphenol and Bisphenol A (endocrine disrupting compounds), Estrone, 17 $\beta$ -estradiol and 17 $\alpha$ -ethinylestradiol (hormones). The determination of OM was executed on both the solid and liquid phase of sludge via liquid and gas chromatography, on samples previously enriched by means of the solid phase extraction.

## Results

As concern the “background” concentration in sludge, musk fragrances were the most concentrated OM, with concentrations of hundreds of  $\mu\text{g/L}$ , followed by ibuprofen (tens of  $\mu\text{g/L}$ ). On the contrary, several compounds (celestolide, diazepam, naproxene, diclofenac, erythromycin, sulfamethoxazole, roxithromycin, nonylphenol, octylphenol) were unquantified/undetected in all samples. The concentrations of OM were quite variable in the 2 sampling campaigns.

As concern the effect of anaerobic digestion on the removal of OM, two macro-categories were defined, i.e. *high* and *low* removal efficiency. High removal was recorded for 17 $\alpha$ -ethinylestradiol, trimethoprim, citalopram and fluoxetine; on the contrary, low efficiency for galaxolide, ibuprofen, tonalide and carbamazepine.

As concern the solid-liquid distribution coefficient ( $K_d$ ) the obtained values were in agreement with literature data: e.g., musk fragrances (the most concentrated OM) recorded  $\log K_d$  equal to 4–5, meaning that sorption was the most relevant process. Other compounds (trimethoprim, ibuprofen and carbamazepine) obtained  $\log K_d < 2$ , i.e. they are mainly found in the liquid phase.

## Highlights

- A wide range of OM was detected both in the liquid and solid phase of sewage sludge.
- The efficiency of the AD process was compound-specific: some OM were highly removed (e.g. trimethoprim), others were only slightly affected by the process (e.g. carbamazepine).

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